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HONEYCOMBED LIMESTONES IN LAKE HURON

BY

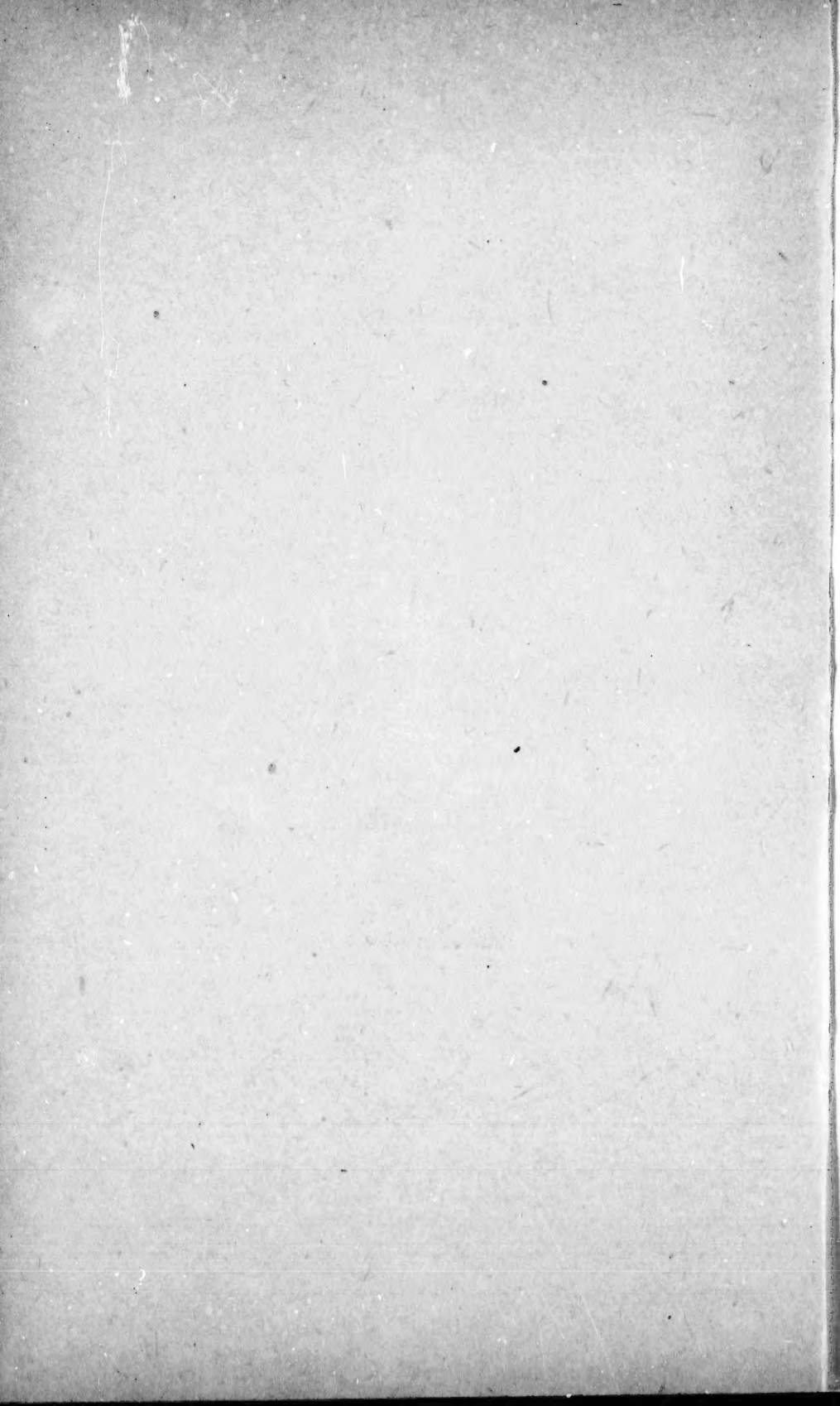
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ROCHESTER

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HONEYCOMBED LIMESTONES IN LAKE HURON

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AREA OF OCCURRENCE AND CONDITIONS.

The limestones in the bottom of a certain portion of lake Huron are undergoing a peculiar kind of erosion, which, from want of better terms to describe the process, may be called honeycombing and pitting.

The portion of the lake in which this phenomenon is most prevalent is that around Grand Manitoulin island, the Indian peninsula and in Big gap, which lies between them and connects the main body of the lake with Georgian bay. This curious form of erosion appears to be progressing most rapidly under a considerable depth of water, say, from 50 or 100 feet, down to greater depths, but it may also be going on in shallower water. The existence of the honeycombed limestone all over the bottom of this part of lake Huron is well known to every one living in the vicinity, and especially to the fishermen, to whom it is a great source of annoyance from their nets catching upon it. Visitors carry away specimens of it every summer as curiosities, but, so far as the writer is aware, no one has yet described its occurrence, attempted to explain its cause, or reported a similar condition elsewhere. The phenomenon therefore appears to be rare, if not unique, and worthy of a description from a geologic standpoint.

Grand Manitoulin island is 80 miles in length. Along its southern side the undisturbed Silurian limestones slope very gently southward under the lake, so that shallow water extends a considerable distance from shore. On surfaces which have been long exposed to the weather or to the wearing action of the waves the pitting is more or less effaced, but wherever they have been covered by the water or otherwise sheltered it is still plainly visible. In the autumn the whitefish come into shallow water to spawn, and the fishermen say that the rough limestone bottom, here described, is a favorite resort for this purpose. As its inequalities protect the eggs from destructive currents and predaceous fishes, it may be said to serve an economic purpose.

PHYSICAL CHARACTERISTICS OF THE ERODED ROCKS.

Various kinds of limestones have been acted upon by this peculiar form of erosion. The unaltered varieties have been completely riddled with cavities, varying from very small holes up to three inches or more in diameter, the average being between half an inch and an inch, but in altered or crystalline limestones or dolomites the pits are mostly larger and shallower. The pitting of these rocks will be more fully noticed further on. In unaltered dolomites one form assumed by the cavities is globular to pear-shaped, and in the process of enlargement they encroach upon one another until only thin walls remain between them, while others coalesce, and ultimately the whole mass becomes separated into a highly eroded skeleton, as shown in figures 1 and 2, plate 13, taken from photographs. Even in this stage, the solid angles between adjacent cavities become perforated by smaller holes, and at length the rock crumbles to fragments, with deeply hollowed concave surfaces. The removal of such a wasted exterior exposes a pitted surface on the next lower layer of limestone, the contiguous cup-shaped hollows usually occupying the whole area. A completely sculptured surface resembling this may also be produced by the direct solvent action of the water without the intervention of the globular honeycombing. Large areas showing surfaces of this kind, which had been eroded at a considerable depth, may now be seen in the clear, shallow water or exposed to the air, owing to the lowering of the level of the lake, while wide borders of nearly horizontal limestone beds, similarly eroded, are exposed in some localities between the margin of the water and the wooded shore. These extremely eroded surfaces have a striking appearance, and the sharp and pointed edges of the pits would be painful to walk on without thick soled boots.

Another form which these cavities take is finger-shaped, crowded together and deeply indented, or of such a shape as would be completely filled by inserting the sharp end of a cigar. As in the other forms, the cavities at their tops adjoin each other, leaving no space between them.

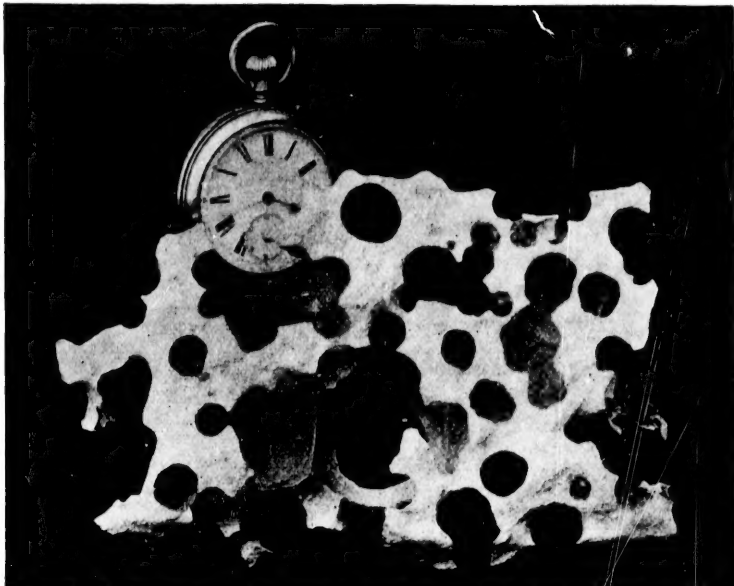


FIGURE 1.—VIEW AT A RIGHT ANGLE TO THE BED-PLANE.

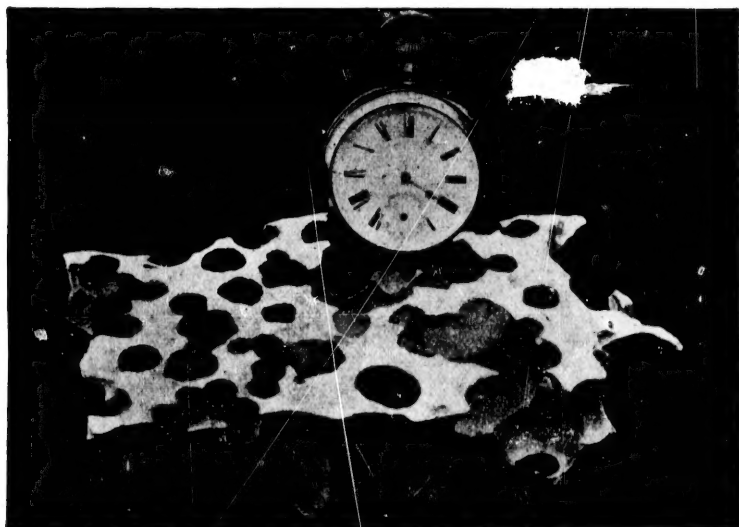
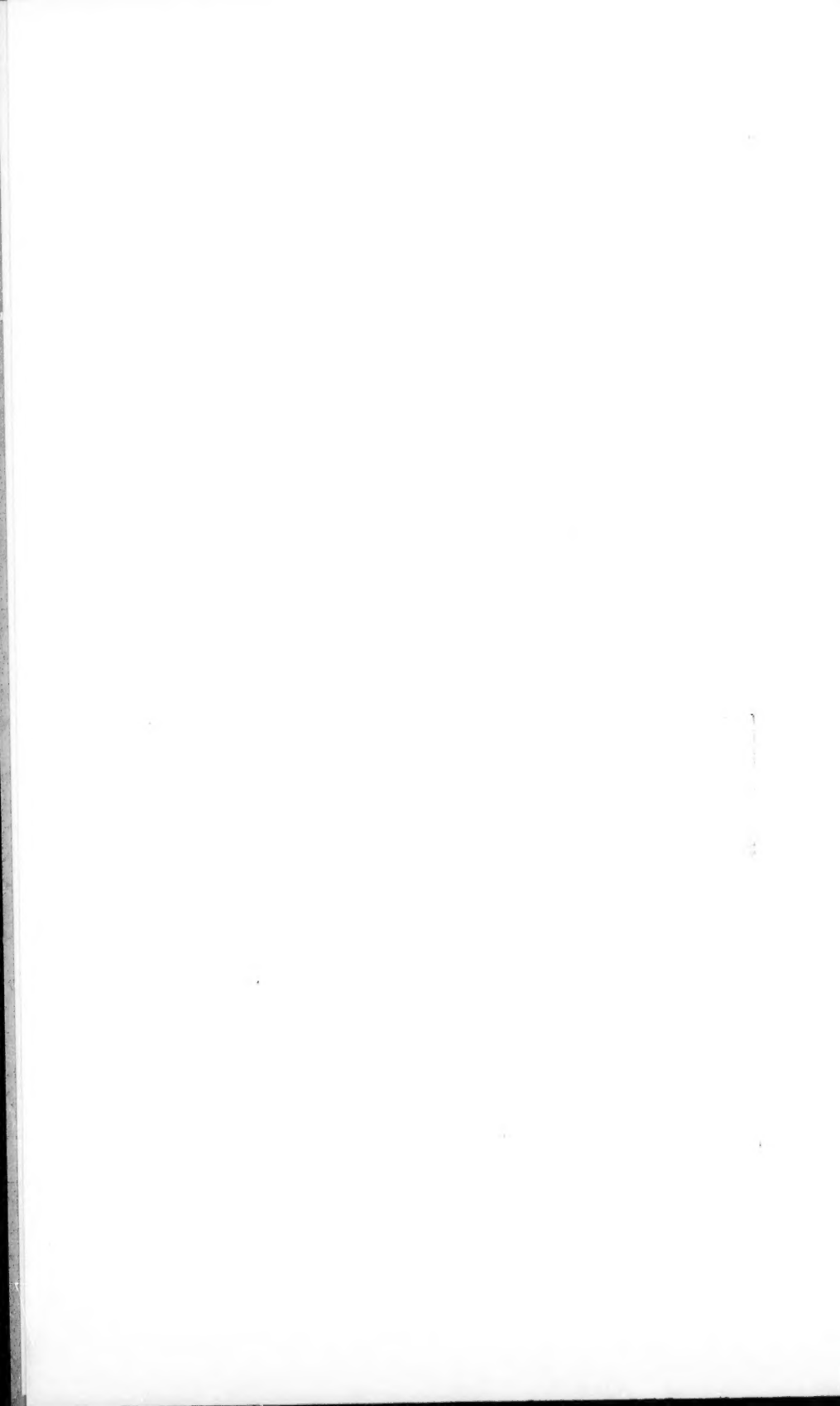
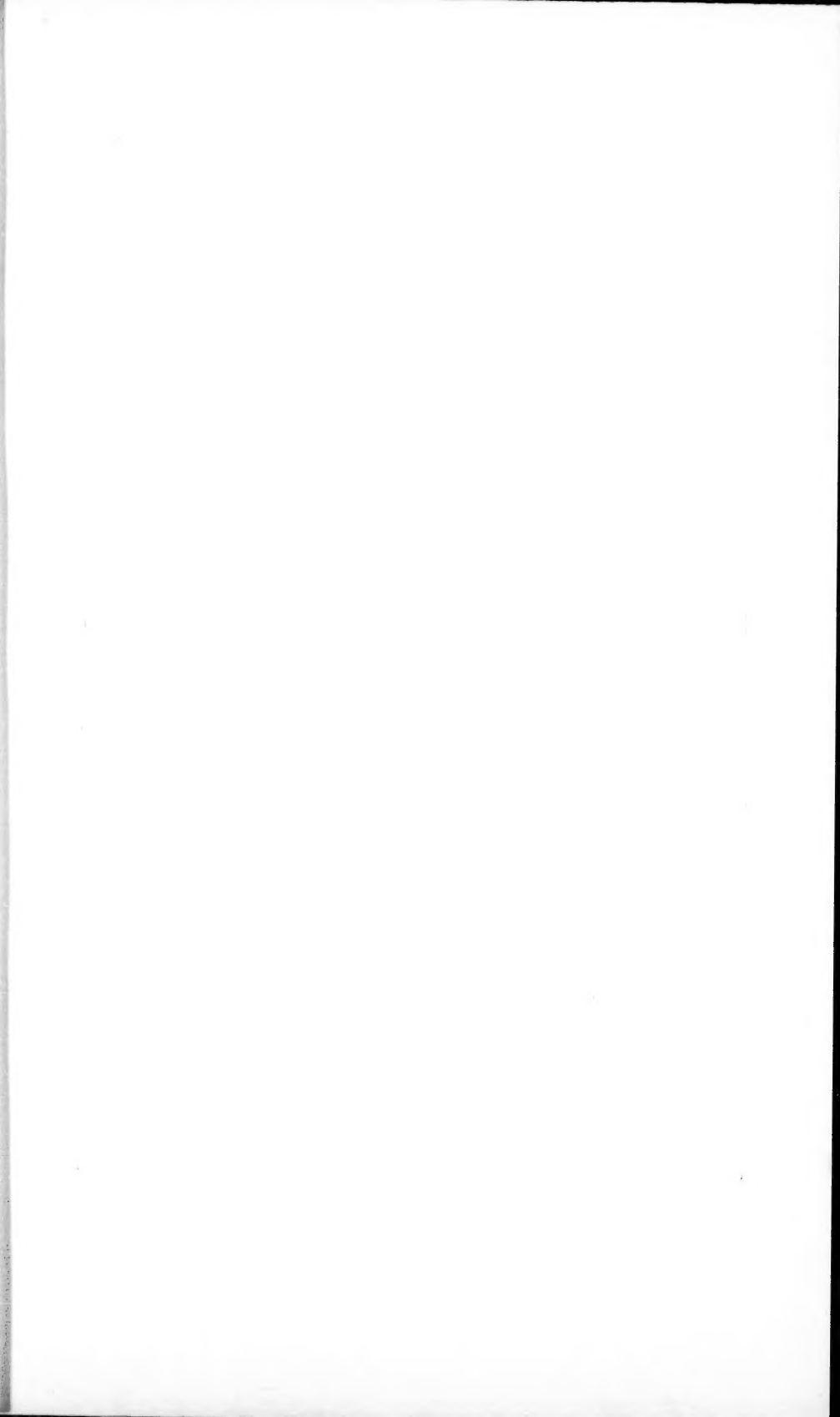


FIGURE 2.—VIEW OF SAME SPECIMEN AT AN ANGLE OF 45° TO THE BED-PLANE.

HONEYCOMBED DOLOMITE.

From South Bay Mouth, Manitoulin Island, Ontario, Canada.





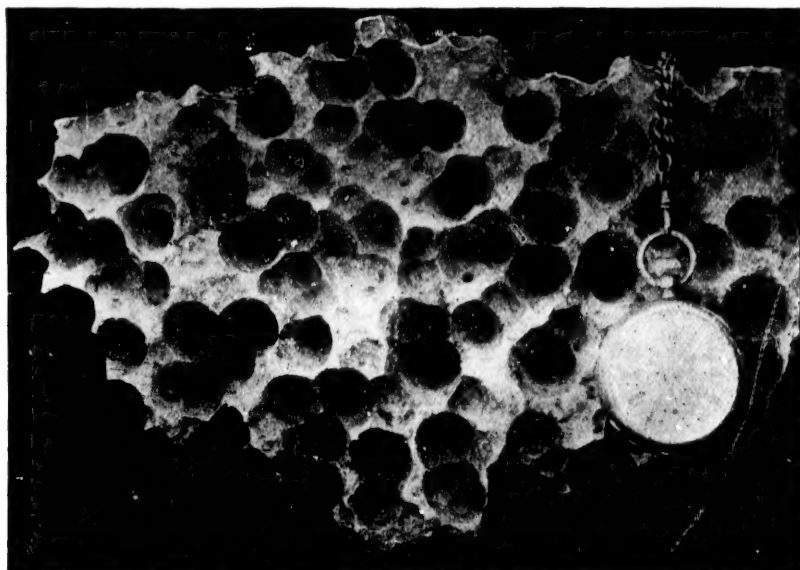


FIGURE 1.—VIEW OF UNDER SURFACE AT A RIGHT ANGLE TO THE BED-PLANE.

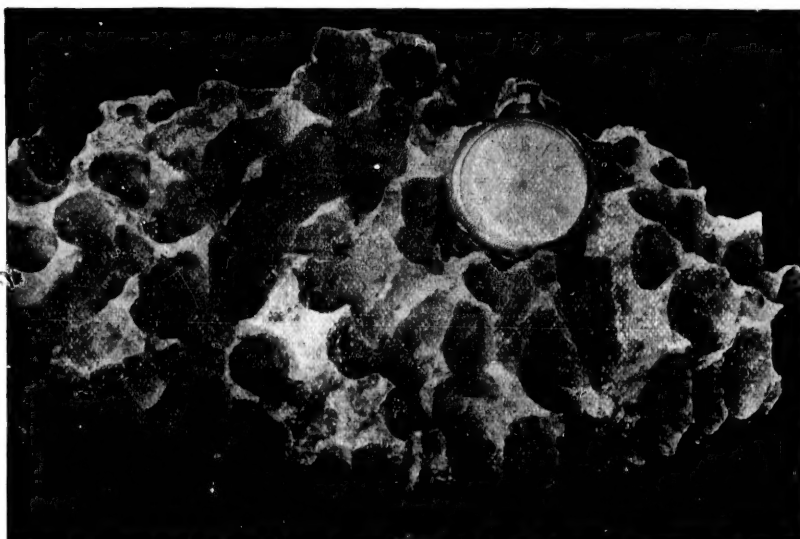


FIGURE 2.—VIEW OF SAME SPECIMEN AT AN ANGLE OF 45° TO THE BED-PLANE.

PITTED LIMESTONE OF THE BLACK RIVER FORMATION.

From Little Cloche Island, Ontario, Canada.

This variety of deeply pitted surface resembles limestone which has been thoroughly riddled by the burrows of *Saxicava*. In a well marked case, to be again noticed, where a submerged shelf or hanging ledge was eroded on the under side, the pitting took the form here described. It is well shown in figures 1 and 2, plate 14.

AGE AND ATTITUDE OF THE ERODED ROCKS.

The rocks of Grand Manitoulin and the adjacent islands embrace eight different formations, from the Chazy, in the northern part of the La Cloche island, to the Guelph, on Fitzwilliam island and on the southeastern part of the main island, while dolomites of the Huronian system are met with on many of the islands of the channel between the Manitoulin chain and the main north shore of lake Huron. The Chazy is represented by brownish red and green marls and fine grained white sandstone; the Black River consists of pure limestone and yellow weathering dolomites; the Trenton principally of bluish gray limestone, with earthy beds; the Utica of black bituminous shale; the Hudson River of marls, with thin beds of limestone and sandstone; the Clinton of dolomite, with bright red and green marls at the base, while the Niagara and Guelph formations are composed almost entirely of dolomites. The dip is uniformly to the south, at a very low angle, and the naked beds of the higher formations above enumerated slope gently under the lake along the southern sides of all the islands of the Manitoulin group.

EROSION FORMS IN RELATION TO VARIETY OF ROCK.

The largest and most irregular cavities are in the magnesian limestones of the Guelph formation. Their appearance *in situ* is shown in plate 15, which is from a photograph. The globular and pear-shaped varieties, shown in figures 1 and 2, plate 13, are excavated in somewhat argillaceous dolomites of the Niagara and Clinton formations. The cup-shaped hollows are commonest in the pure limestones of the Hudson River, Trenton and Black River and in the dolomites of the last mentioned formation. The finger-shaped honeycombed structure was found principally in the pure limestone of the Black River formation, while the smoother and rather larger excavations are characteristic of the Huronian dolomites. The shallower varieties of this form of pitting resemble that of a well eroded *aërolite*. The occurrence of these various forms of honeycombing and pitting in such a variety of limestones and dolomites in this portion of lake Huron proves that the phenomenon is not due to anything unusual in the general composition or to any chemical peculiarity of a particular variety of rock, but to some outside cause. The various forms which the erosion takes, however, show a slightly unequal solubility connected in some way with the internal structure of the rock;

otherwise it would be of a more uniform character, since it is due to some common external cause operating alike upon them all.

The dissolving of the unaltered limestones or dolomites goes on at right angles to the bedding or directly downward or upward, as the rocks are practically horizontal, never at an oblique angle nor horizontally, which, in the absence of some inhibiting cause, might easily take place in loose masses which lie at all angles on the bottom of the lake. On isolated blocks, where the sides have been as freely exposed to the water as the top, the solvent process appears to prefer to work downward from the "quarry bed" and not to eat inward from the sides.

Experiments made by Professor Goodwin, of Queen's University, Kingston, on the action of solvents on slowly soluble substances seem to show that the tendency of solution is strongest directly upward and downward. This, together with a faint concretionary structure, to be noticed further on, may help to account for these forms of erosion.

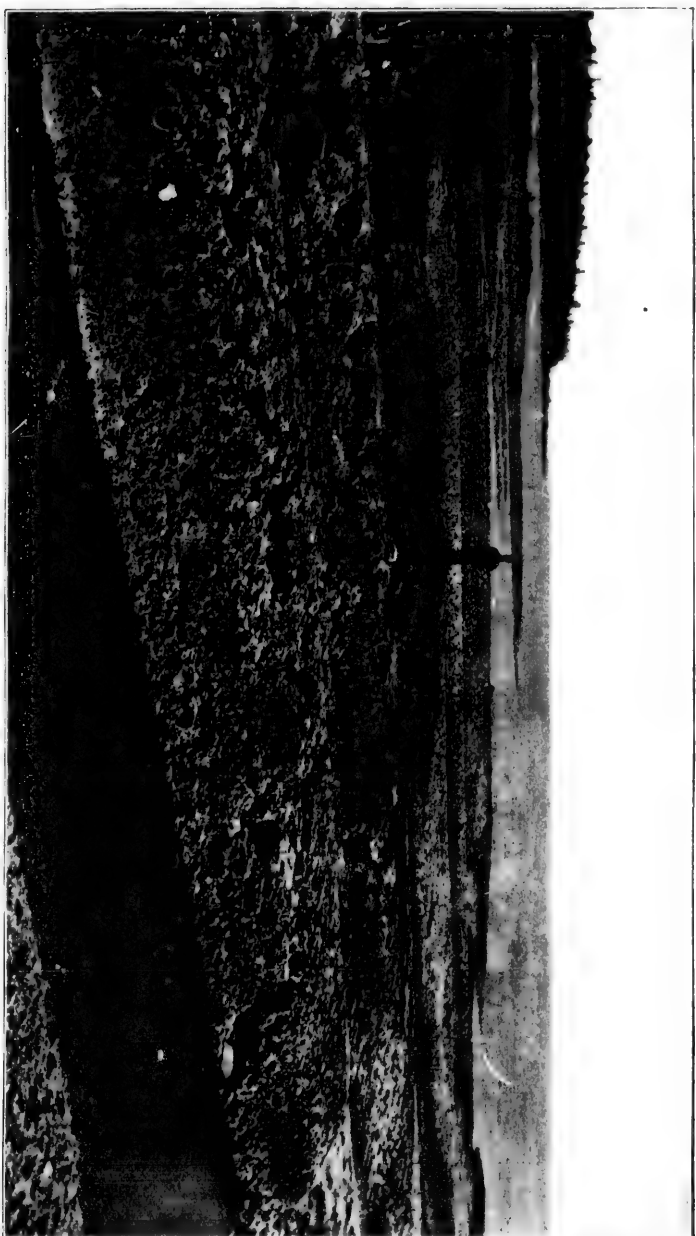
Allusion has been made to a well marked case, where the pitting has progressed directly upward from the under surfaces of beds of pure limestone forming the roof of an overhanging ledge or shelf which had been submerged when the lake was a little higher than it is at present. This occurs along the east side of The Narrows between Little Cloche island and the southern part of Cloche peninsula. The rock, which belongs to the Black River formation, consists of a soft bluish grey limestone containing a little argillaceous matter. The tapering finger-shaped pits are closely crowded together and they penetrate upwards from two to four inches from the general outline of the roof. Silicified fossils project from the walls into these pits, and when the rock is broken across a discoloration of iron oxide is seen to extend a short distance all round the wall of each one. Plate 14 illustrates these pits.

POSSIBLE ORIGINS OF THE EROSION.

BORINGS OF MOLLUSKS.

The writer may not have arrived at a correct explanation of these curious forms of erosion, but he will endeavor to state the suggestions which have occurred to him in regard to their origin, along with a description of the circumstances connected therewith. Many theories to account for these phenomena may present themselves both to those who have and those who have not seen them on the ground, and it may be as well here to notice briefly the more obvious ones.

Cavities resembling some of those above described are made in rocks by boring mollusks, such as *Saricava*, *Pholas*, *Petricola*, *Callista*, *Tapes*, *Venerupis* and *Lithodomus*. The case of the zones on the marble pillars of the temple of Jupiter Serapis, at Puzzuoli, eroded by lithodomi,



GLACIATED AND HONEYCOMBED DOLOMITE OF THE GUELPH FORMATION.

South Bay Mouth, Manitoulin Island, Ontario, Canada.



which has been rendered classic by Lyell in his "Principles of Geology," will occur to every geologist. The cavities formed by boring mollusks are, however, burrows which are of pretty uniform calibre, or increase in diameter with the depth, owing to the growth of the animal as it proceeds. They are generally many times deeper than wide, whereas those under consideration are either globular or short by comparison, and they contract instead of enlarge toward the bottom.

ACTION OF SPONGES AND ALGÆ.

A small sponge, *Cliona celata*, makes burrows in the shells of oysters, and this fact led to the supposition that possibly some species of fresh-water sponge might have aided in deepening or enlarging the cavities under discussion, or in determining their form by the production of small quantities of an organic acid, either during life or upon decomposition, but no evidence could be found in support of this idea. The remains of branching fresh-water algæ may be seen in some of the cavities, but they do not appear to have exercised the least influence in their production. The lower or jelly-like algæ of fresh water do, however, possess the power of dissolving limestone. The journal of the Royal Microscopical Society for October, 1894, says, on page 597, that—

"Professor F. Cohn points out the important part played by very lowly organized algæ—Phycochromaceæ and Cyanophyceæ—in the formation of calcareous and silicious rocks. Many beds of marble and travertine have been formed in this way. He further enumerates the algæ that are known to destroy calcareous rocks by erosion. In all fixed algæ there appears to be this contrast between the basal cells and the rest of the filament; that the former excrete an acid which dissolves lime, while the latter has the power of depositing a soluble lime-salt between the filaments, but within the mucilage which is excreted from the sheath."

WEARING ACTION OF PEBBLES.

A popular notion current among many of the residents of the localities where the pitted surfaces occur is that the cavities have been worn by the whirling of pebbles and sand in a manner analogous to the formation of potholes at rapids and falls. That they have not been thus formed is obvious from the following reasons, selected from among others:

Their shapes do not correspond with this mode of formation.

They occupy the whole surface of the rock, whereas potholes occur at irregular intervals.

The walls of the cavities are generally uneven or rough, and delicate silicified fossils often project from them or stretch completely across the cavities, whereas the wearing action of rotating pebbles and sand would have produced smooth and cylindrical walls.

No pebbles are ever found in them except such as can be shown to have been placed there subsequent to their excavation. If these cavities

had been due to this cause, their occurrence would not be confined to the limestones of lake Huron, but would be a general phenomenon in connection with similar rocks all over the world. On the contrary, the pebble theory is not sustained by facts anywhere. Pebbles washed by currents passing over rocks or grated against them by the waves, not only do not pit or honeycomb rocks, but they have the opposite effect and wear them smooth.

It is true that gravel may now be seen scattered over local pitted surfaces which have been laid bare by the recession of the lake, but on examining cases of this kind it is always manifest that the gravel was placed upon such surfaces long after the completion of the pitting.

The occurrence of the cavities equally on the tops of loose blocks of limestone and on the solid beds is another objection to this theory.

A final objection is the fact that some of the most beautiful examples of deep pitting are found on the under surfaces of overhanging beds, the eroding agent having worked upward in a free body of water.

ACID WATER THE PROBABLE CAUSE OF THE EROSION.

Having eliminated all the possible causes which have suggested themselves as being unlikely to have produced the erosion under discussion, the question arises: To what must we attribute it? It appears most probable that the cause will be found in the differential solubility of the rock in the water of the lake itself. The slight difference in the solubility of those parts of the rock which give rise to the cavities is likely due to its internal structure, which originated, in the first place, at the time of the formation of the limestones or dolomites themselves. The eroded beds are not generally those which are largely made up of organic remains, but oftener those which have been due to chemical precipitation. There are, however, exceptions to this general rule which add to the difficulty of accounting for this singular phenomenon. In the process of consolidation of chemically formed beds in which lime, magnesia and argillaceous matters were present, there would naturally be more or less tendency to concretionary action around certain points or centers, thus giving rise to slight differences in composition. Even if such concretionary structure were too obscure to be readily noticed, the probability of its existence in the rocks of the above composition will be readily admitted; but in some cases, especially where oxide of iron is present, this structure may be detected in the form of obscure concentric lines. The globular shape of the cavities is a fact which points to this origin. But, if this be true, it may be asked, why are similar limestones not always eroded in this manner when they are covered by fresh water? The explanation of the difference is probably to be found in a sufficiently acid condition of the water of this part of the lake to slowly dissolve the limestones.

The solvent action of the slightly acidulated water is, no doubt, aided by certain conditions favorable to it in the present case, but which might be absent elsewhere, even if the requisite amount of acidity existed. The water of this part of lake Huron is perfectly limpid and free from suspended impurities, so that there is nothing to check the progress of the dissolving process, no matter how slowly it may be going on. That it has been exceedingly slow in its operation is shown by the pitted or honey-combed surfaces retaining their glaciated forms. As the basin of lake Huron has no doubt been filled with water since the disappearance of the ice-sheet, the time required for the erosion under consideration must have been many thousands of years, but the proportion of acid in the water probably increased gradually, as the explanation to follow will show.

SULPHURIC ACID IN THE WATER AND ITS SOURCE.

Although the water of this part of lake Huron has not been analyzed, it appears to contain a notable proportion of sulphuric acid. It has the property of slowly reddening vegetable matter, purple or blue. Its corroding action on tin pails and pans is a source of annoyance and loss to housekeepers and campers who use the water for domestic purposes. A new tin pail, if kept filled with the lake-water, will in a few days show rusty excrescences in the bottom, which increase rapidly and soon perforate the vessel. The water of the portion of the lake where honeycombing of limestones is most obvious is distinctly harder than elsewhere, probably owing to the pressure of sulphate of lime.

The source of the sulphuric acid may be looked for in the Huronian rocks lying to the northward of the lake. It is remarkable that the portion of the lake in which this form of erosion of limestone takes place lies directly in front of that part of the north shore occupied by the Huronian rocks, and receives several considerable rivers which drain an immense area of rocks of the same age. They are mostly of volcanic origin and are rich in sulphides, whereas all the other rocks around the lake are comparatively free from them.

Sulphides of several metals, but especially of iron, are disseminated through most of the Huronian rocks. Pyrites and pyrrhotite are particularly abundant in the greenstones, and these form a considerable proportion of the series. The two sulphides referred to occur both as disseminated grains and in the form of numerous masses, some quite large, such as those around Sudbury, a few of which are being worked for nickel. The decomposition of these sulphides upon the surface of the rocks and along their fissures and joints produces iron-sulphate, which is carried away by the streams, where its presence is frequently shown by the precipitation of a part of the iron. In the swamp at the Murray mine near Sudbury, where a large mass of pyrrhotite and chal-

copyrite comes to the surface, the presence of acid sulphate could be detected by the taste of the water, and when the latter, containing as it does vegetable matter also, was used experimentally for the boilers, it gave off a most offensive smell and had a very corrosive effect. The streams of the whole of this Huronian region no doubt receive many contributions of acidulated water from similar sources. As the decomposition of the greenstones and other pyritiferous rocks, and also the oxidation of the drift materials derived from them, proceeds, the quantity of acid derived from them and carried into the northern part of lake Huron will increase. At The Narrows between Cloche peninsula and Little Cloche island, as already mentioned, the pits in the soft argillaceous grey limestone are surrounded by a zone stained by iron oxide. This is just what might be expected to result if such a rock were being slowly dissolved by iron-sulphate and, therefore, this fact helps to support the present hypothesis.

The fresh rock-surfaces and unoxidized drift left at the close of the Glacial epoch would produce a much smaller proportion of sulphuric acid in a given time, and we therefore suppose that the erosion of the limestones in the bottom of the northern part of lake Huron went on even more slowly then than now.

Another example may be cited here of water containing sulphuric acid which has been derived apparently from volcanic rocks. A sample from the shallow fresh-water in the estuary of the Nelson river, Hudson bay, was taken by the writer to the late Professor William Dittmar, the well known authority on water analyses, and he found it to contain no less than 4.73 grains of sulphuric acid to the imperial gallon.* The source of this acid appeared to be the drift-material which had come from the volcanic rocks of the central or eastern part of the bay.

CONCLUSIONS.

The conditions which have contributed to the production of the peculiar forms of erosion above described appear to have been :

1. The internal structure of the limestone itself.
2. A small quantity of acid in the water acting for a great length of time.
3. A considerable depth of water, the hydrostatic pressure seeming to promote the dissolving of the rock.
4. Freedom from sediment during the long time required.
5. The rock must be exposed to the open or free action of the water.
6. Shifting currents in the water would also appear to assist the process.

*See Appendix V, Report C, of the Canadian Geological Survey for 1879-'80, p. 78.

